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1. Introduction

*There are 2 basic precipitation retrieval methods using passive microwave measurements:

- 1) Emission-based: Based on the tendency of liquid precipitation to cause an increase in brightness temperature (BT) primarily at frequencies below 22 GHz over a radiometrically cold background, often an ocean background (e.g., Spencer et al. 1989; Adler et al. 1991; McGaughey et al. 1996).
- 2) Scattering-based: Based on the tendency of precipitation-sized ice to scatter upwelling radiation, thereby reducing the measured BT over a relatively warmer (usually land) background at frequencies generally ≥ 37 GHz (e.g., Spencer et al. 1989; Smith et al. 1992; Ferraro and Marks 1995).

*Passive microwave measurements have also been used to detect intense convection (e.g., Spencer and Santek 1985) and for the detection of hail (e.g., Cecil 2009; Cecil and Blankenship 2012; Ferraro et al. 2014).

*The Global Precipitation Measurement (GPM) mission expands upon the successful Tropical Rainfall Measuring Mission program to provide global rainfall and snowfall observations every 3 hours (Hou et al. 2014).

*One of the instruments on board the GPM Core Observatory is the GPM Microwave Imager (GMI) which is a conically-scanning microwave radiometer with 13 channels ranging from 10-183 GHz.

*Goal of this study: Determine the signatures of various hydrometeor species in terms of BTs measured at frequencies used by GMI by using data collected on 3 case days (all having intense/severe convection) during the Mid-latitude Continental Convective Clouds Experiment conducted over Oklahoma in 2011.

3. Overview

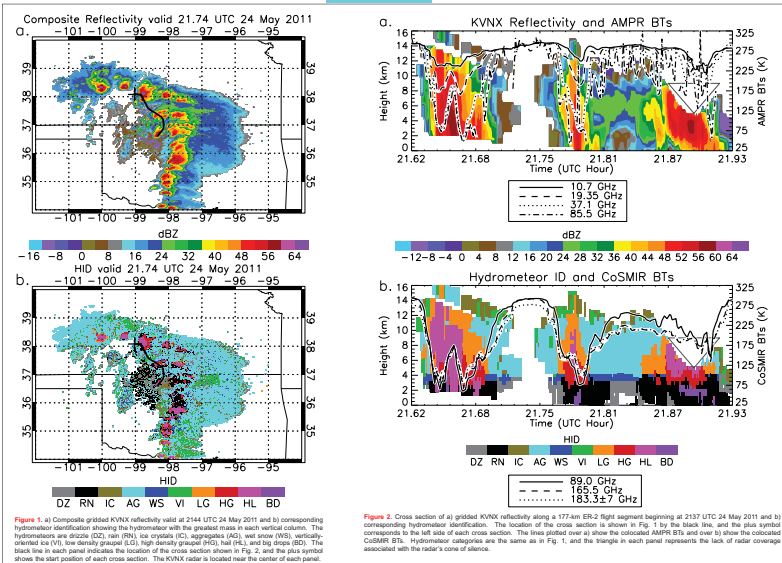


Figure 1. Overview of hydrometeor identification. Panel (a) shows a map of Oklahoma with a color-coded reflectivity (dBZ) scale from -16 to 64. Panel (b) shows a map of Oklahoma with a color-coded hydrometeor ID scale from -12 to 64. Panel (c) shows a cross-section of hydrometeor ID and CoSMIR BTs. Panel (d) shows a cross-section of hydrometeor ID and CoSMIR BTs. Panel (e) shows a cross-section of hydrometeor ID and CoSMIR BTs. Panel (f) shows a cross-section of hydrometeor ID and CoSMIR BTs.

2. Method

- *Data: Passive microwave BTs collected using the Advanced Microwave Precipitation Radiometer (AMPR) and Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR), dual-polarimetric radar data from the KVN WSR-88D radar at Vance Air Force Base in Oklahoma.
- *3 case days were examined, including 22 April and 23-24 May 2011 (AMPR data available on 22 April and 24 May while CoSMIR data available on 23-24 May).
- *Radar data was converted from its native polar coordinates to a Cartesian grid that stretched 600 by 600 km centered on KVN and from the surface to a height of 16 km with a horizontal (vertical) resolution of 1.0 (0.5) km.
- *Fuzzy-logic hydrometeor identification (HID) based on Liu and Chandrasekar (2000) and Dolan and Rutledge (2009) was applied to gridded radar data.
- *To compare the HID with the passive microwave pixels, the passive microwave pixels closest to nadir were matched with vertical profiles of gridded KVN data that occurred closest in time and space to each AMPR or CoSMIR pixel.
- *To minimize the effect of the signal from one hydrometeor species dominating the signal from other species and better isolate the signal from each species separately, a subjective hierarchy of hydrometeor categories was applied. Each hydrometeor type was assigned a certain priority, and the type with the greatest priority in each profile was assigned to that column. The big drops category was given the highest priority followed by hail, high density graupel, low density graupel, rain, wet snow, aggregates, ice crystals (which were combined with vertically-oriented ice), and drizzle.

4. Frequency Distributions

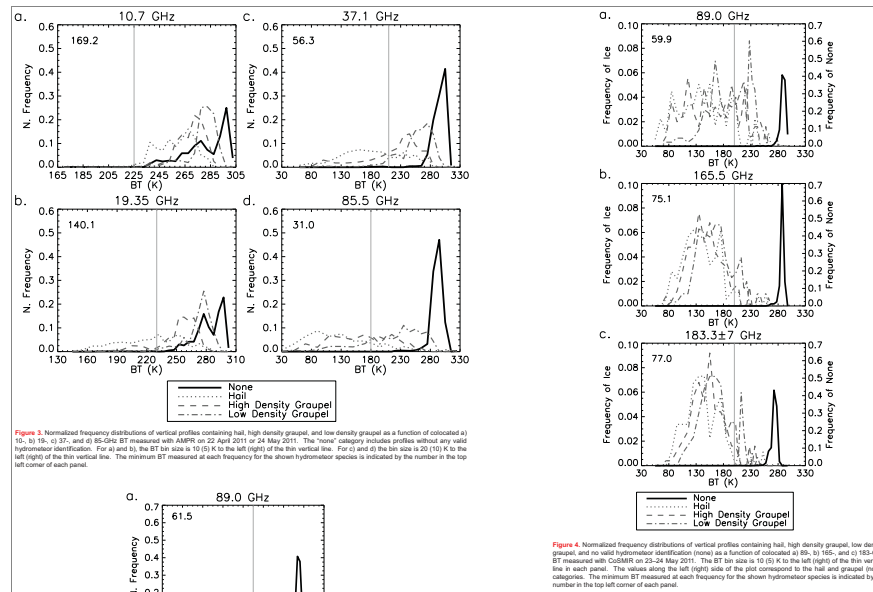


Figure 3. Normalized frequency distributions of vertical profiles containing hail, high density graupel, and low density graupel as a function of collocated a) 10.7, b) 37.1, c) 89.0 GHz BT measured with AMPR on 22 April 2011 or 24 May 2011. The BT bin size is 10 (5) K to the left (right) of the first vertical line in each panel. The minimum BT measured at each frequency for the shown hydrometeor species is indicated by the number in the top left corner of each panel.

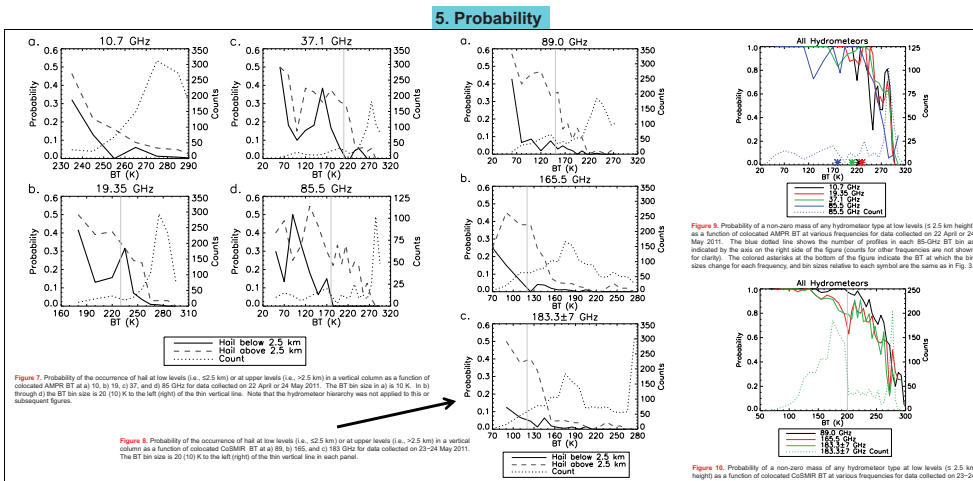


Figure 7. Probability of the occurrence of hail at low levels (i.e., <2.5 km) or at upper levels (i.e., >2.5 km) in a vertical column as a function of collocated AMPR BT at 10.7, 37.1, and 89.0 GHz for data collected on 22 April or 24 May 2011. The BT bin size is 10 (5) K to the left (right) of the first vertical line in each panel. Note that the hydrometeor frequency was not applied to this or subsequent figures.

5. Probability

- *Hail is associated with a strong scattering signature at all frequencies examined, including 10 GHz.
- *Frequencies ≤ 37 GHz show the strongest distinction between hail and other hydrometeor types.
- *Low-level hail becomes probable for a BT below 240 K at 19 GHz, 170 K at 37 GHz, 90 K at 85 GHz, 80 K at 89 GHz, 100 K at 165 GHz, and 100 K at 183 GHz.
- *Graupel may be distinguished from hail and profiles without any hydrometeor species by its strong scattering signature at higher frequencies (e.g., 165 GHz) and its relative lack of scattering at frequencies ≤ 19 GHz.
- *Liquid precipitation can be best distinguished from no-rain profiles over land when associated above with hail and/or graupel (hydrometeor species with a strong ice scattering signature).
- *Probability of surface precipitation becomes very likely (~100%) for a BT below 230 K at 10 GHz, 250 K at 19 GHz, 240 K at 37 GHz, 230 K at 85 GHz, 220 K at 89 GHz, 140 K at 165 GHz, and 140 K at 183 GHz.
- *Note that these results are valid over intense convection for a few days over Oklahoma in spring 2011 (sample size is small).

6. Conclusions

7. References

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